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technical supplement

WASHINGTON

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16. ABSTRACT

This report is a technical supplement to the1976 REGIONAL ENVIRONMENTAL QUALITY PROFILE (EPA REGION X) and is designed to inform the reader about the general status of the environment within the state of Washington. It is designed to report on the present status of Washington air and water quality, trends in that quality, an analysis of the causes and effects of observed pollution problems and EPA's view of the near term outlook for solving these problems.

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SUPPLEMENT

1976 ENVIRONMENTAL QUALITY PROFILE

FOR WASHINGTON

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1976 ENVIRONMENTAL QUALITY PROFILE SUPPLEMENT FOR WASHINGTON

INTRODUCTION

State, federal, and local environmental quality control agencies maintain monitoring networks to scientifically measure the quality of our environment. These monitoring networks are invaluable in determining where pollution problems exist and to measure the success or failure of abatement and pollution prevention programs.

The Seattle Regional Office of the Environmental Protection Agency annually evaluates all data collected by northwest pollution control agencies and submitted to the EPA computer data storage systems. We feel the public should be made aware of the results of these evaluations. This document and similar future documents are designed to report on the present status of northwest air and water quality, trends in that quality, an analysis of the causes and effects of observed pollution problems and our view of the near term outlook for solving these problems. This report is a technical supplement to the 1976 Regional Environmental Quality Profile and is designed to inform the reader about the general status of the environment within the state.

The reader may find a few inconsistencies between this supplement and the 1976 Regional Environmental Quality Profile due to the continual profile upgrading process which includes improvement of evaluation and presentation techniques. These changes are the result of our readers comments and suggestions. Formulating useful and accurate indices of environmental quality is a difficult task. Additional suggestions for improving the information presented in this document would be appreciated. Please direct your comments to the Office of the Regional Administrator, U. S. Environmental Protection Agency, 1200 Sixth Avenue, Seattle, Washington 98101.

REGIONAL AIR QUALITY PROFILE

OVERVIEW

Air pollution--as pollutant concentrations in excess of those established by National health-related air quality standards--occurs in every State in Federal Administrative Region X. Standards for four of the most widespread pollutants were exceeded in the State of Washington for the three year period ending in 1974. Alaska and Idaho exceeded standards for two of the four. Three standards were exceeded in Oregon. Frequency of excessive pollutant concentrations, as measured by number of violation-days, was greatest in sparsely populated Idaho, least in Oregon. (A violation-day, for the purposes of this report, was established whenever a standard was exceeded in a county.) More serious "alert level" pollutant concentrations were recorded most often in Alaska, least often in Oregon.

TABLE 1 - REGION X STATES

	Concentrations Exceeding Standard				Violation-Days	
	Carbon Monoxide	Photo Oxidants	Particulate Matter	Sulfur Dioxide	Standard Exceeded	Alert Level
Alaska	X		X		412	174
Idaho			X	X	446	149
Oregon	X	X	X		301	40
Washington	X	X	X	X	368	48

Excessive pollutant levels were concentrated in nine Region X communities that together accounted for 72 percent of all violation-days and 74 percent of all alert level violation-days. The core cities of the Region's seven standard metropolitan statistical areas were responsible for just under half of all violation-days and just under two-fifths of all alert level violation-days. But two fairly small communities, Fairbanks, Alaska and Kellogg-Wallace, Idaho, exceeded any of the larger cities in numbers of times excessive pollutant concentrations were recorded, and were responsible for almost half of all recorded pollutant concentrations above the alert level.

TABLE 2 - PRINCIPAL CITIES

	Concentrations Exceeding Standard				Violation-Days	
	Carbon Monoxide	Photo Oxidants	Particulate Matter	Sulfur Dioxide	Standard Exceeded	Alert Level
Seattle	X	X	X		149	16
Portland	X	X	X		165	30
Spokane	X		X		82	3
Tacoma	X	X	X		43	5
Anchorage	X		X		142	90
Boise			X		11	6
Eugene	X	X	X		56	2
Salem	X	X			23	1
Fairbanks	X		X		203	73
Kellogg-Wallace			X	X	217	69

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A great deal of Region X's air pollution can be attributed to the automobile. Just under half of Alaska's violation-days can be traced to the automobile and the bulk of Oregon's and Washington's problems (in violation-days) can be traced to the automobile. The bulk of Oregon's and Washington's standards violation problems were due to carbon monoxide and photochemical oxidant concentrations that occurred around the largest cities of the two States. Those pollutants could be traced almost entirely (i.e., 80 to 90 percent) to automobile exhausts. Because well over half of the Region's population lives in and around the six cities in which such pollution occurs, population exposure to risk as a consequence of automobile emissions is a significant public health problem of the Pacific Northwest and Alaska.

TABLE 3 - AUTO-RELATED VIOLATION DAYS

Alaska	42.2%
Anchorage	16.9%
Fairbanks	77.8%
Idaho	No Data
Oregon	85.0%
Portland	97.6%
Eugene	85.7%
Salem	100.0%
Washington	66.8%
Seattle	99.3%
Spokane	82.9%
Tacoma	46.5%
Region X	45.1%

AIR QUALITY IN WASHINGTON

Under the Clean Air Act of 1970, the Environmental Protection Agency has established National standards that specify maximum permissable levels of pollutant materials in air.

Standards for the principal and most widespread pollutants--total suspended particulate matter, sulfur dioxide, carbon monoxide, photochemical oxidants, and oxides of nitrogen--are divided into two categories. Primary standards are set at levels intended to protect human health. Secondary standards are set at levels intended to protect against other forms of damage caused by air pollution.

The material that follows is an attempt to describe simply what is known about air quality in the State of Washington in terms of its adherence to National primary air quality standards. Those standards have been established to protect against the following specific health effects that have been demonstrated to stem from the particular pollutant:

Total suspended particulates--aggravation of asthma and chronic lung diseases, increased cough, chest discomfort, restricted activity, aggravation of heart and lung disease symptoms in the elderly, increased death rate;

Sulfur dioxide--aggravation of asthma, aggravation of heart and lung disease symptoms in the elderly, increased lung illness, increased death rate;

Carbon monoxide--interference with mental and physical activity, reduced capacity in persons suffering from heart and other circulatory disorders;

Photochemical oxidants--aggravation of asthma and chronic lung disease, irritation of the eye and of the respiratory tract, decreased vision, reduced heart and lung capacity;

Oxides of nitrogen--increased chronic bronchitis.

The material is presented in graphic form. It is intended to depict:

1) where, and how often, primary standards were exceeded in 1974,

2) location and frequency of severe concentrations of health damaging pollutants in 1974,

3) indicated trend of pollutant concentrations in the period 1972 to 1974, and

4) sources of the principal pollutants found to be in excess of the primary standard in 1974.

POLLUTANTS IN EXCESS OF HEALTH STANDARDS

During the three year period ending in 1974, sixteen of Washington's thirty-nine counties experienced recorded concentrations of pollutants that exceeded the allowable maxima specified by primary air quality standards. The counties are ranked in the chart (Figure 1) according to the average number of days per year in which a standard was exceeded.

The standard for particulate matter was the most widely exceeded. Concentrations above the primary standard occurred in fifteen counties.

The standard for carbon monoxide was exceeded on the largest number of days. Total days in which the standard was not met amounted to 224, as compared to 144 days for the combination of all other primary standard pollutants. The standard was, however, exceeded only in four metropolitan area counties.

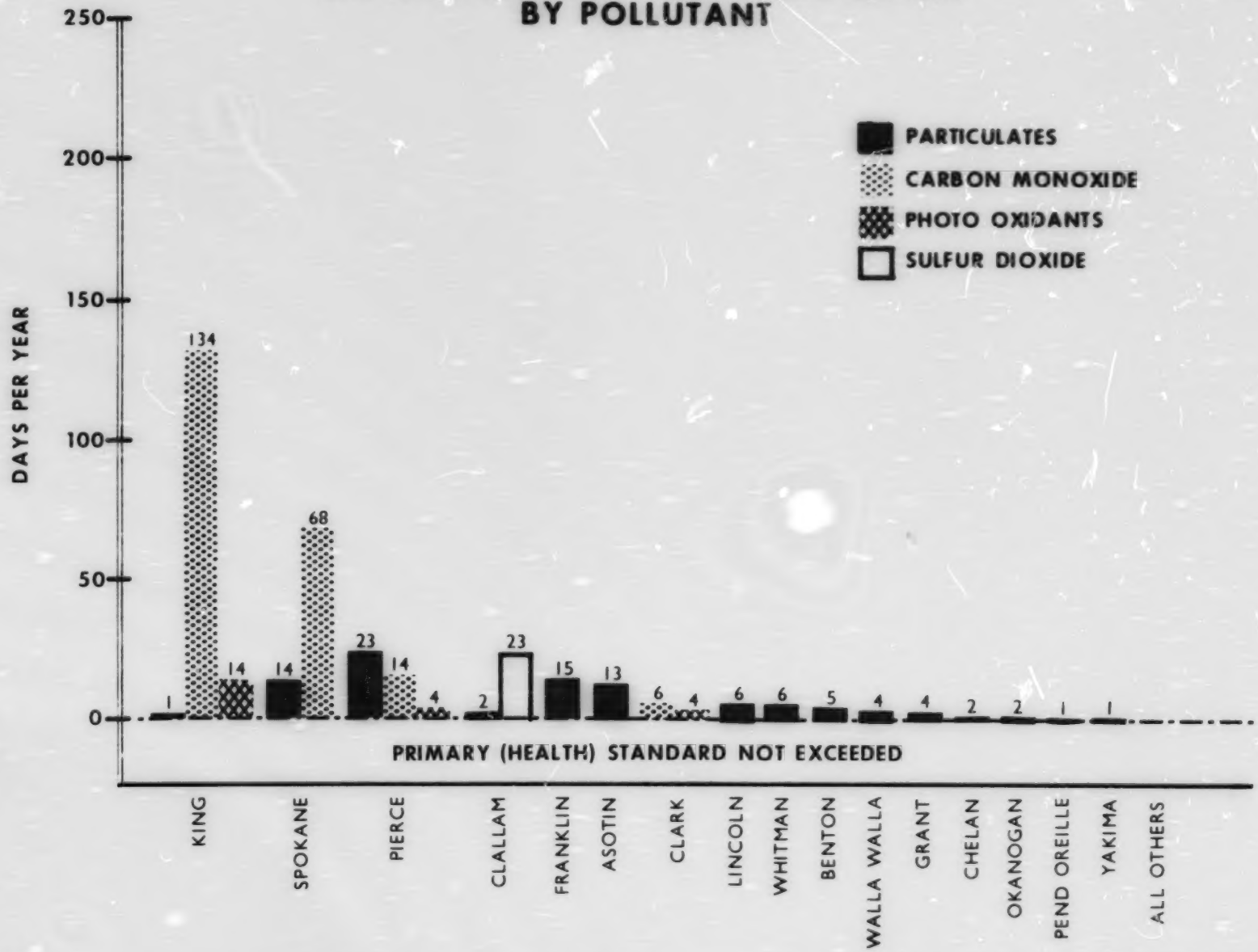
Sulfur dioxide concentrations exceeded the primary standard in a single county, though the frequency with which the standard was exceeded was generally greater than for the more widespread problem of particulates.

The photochemical oxidant standard was exceeded in three of the four metropolitan counties that did not consistently meet the carbon monoxide standard.

Pollutant concentrations in excess of health standards occurred largely in Washington's metropolitan areas. King County experienced 149 days in which standards were exceeded. Together, Pierce, Clark, and Spokane Counties accounted for 135 days. All of the rest of the State produced only 84 days in which health standard levels for pollutants were not met.

Figure 1

WASHINGTON
DAYS EXCEEDING HEALTH STANDARD BY POLLUTANT



SEVERITY OF POLLUTION

Primary air quality standards include three degrees of risk, according to level of pollutant concentrations. The nature of potential health damage is the same at each level, but the probability of damage and the proportion of the population that is predisposed to health impairment increases as the amount of pollutants in air increases. There are distinct thresholds that indicate the degree of risk believed to be associated with certain pollutant concentrations, and these are recognized in the primary air quality standards. As the higher concentrations occur, the enhanced danger of the consequent pollution is designated by an air quality standard category. "Alert" level pollutant concentrations are thought to be significantly more serious than lower concentrations exceeding the primary standard. "Warning" levels are thought to be significantly more serious than alert.

TABLE 4

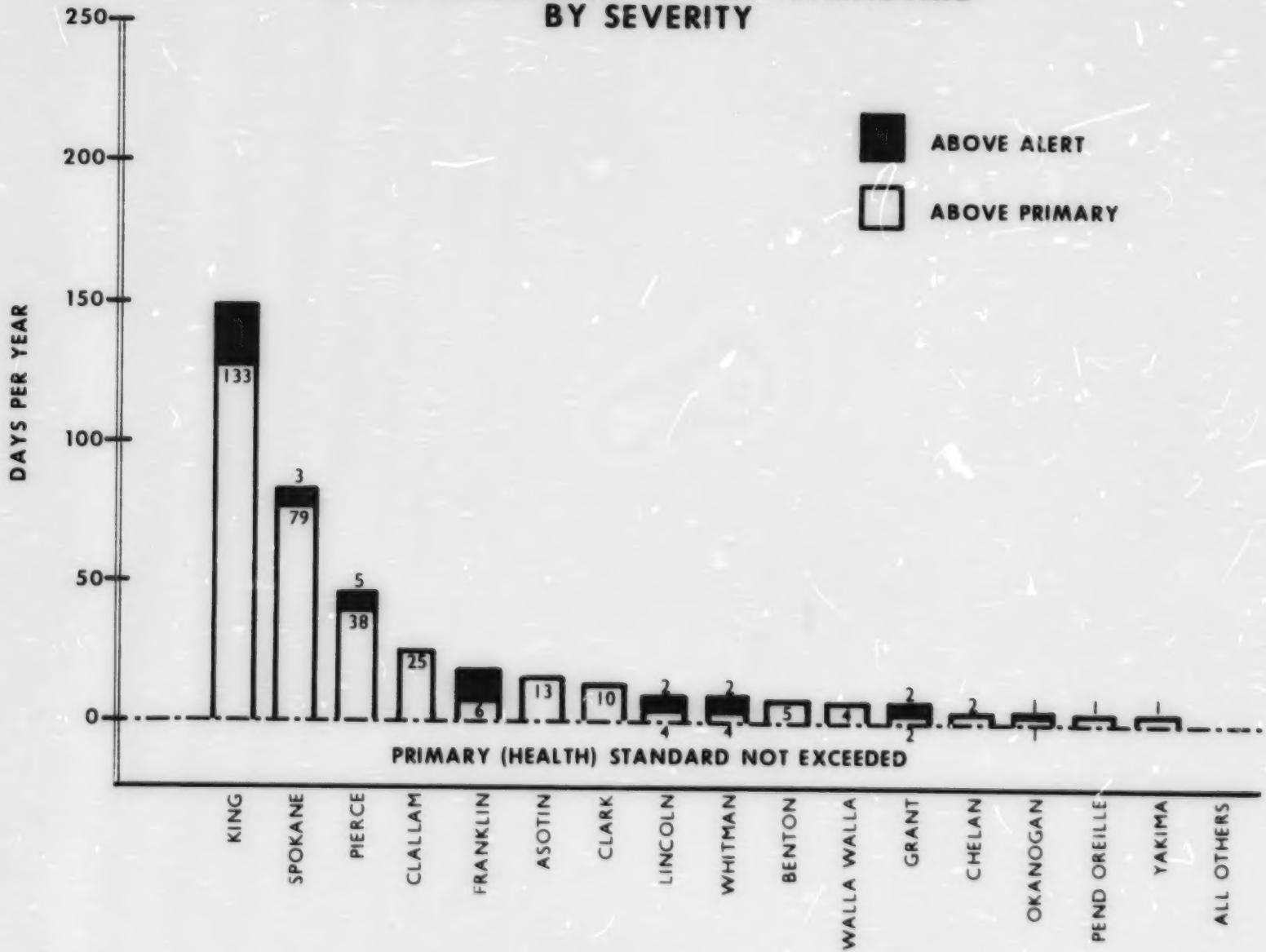
	Threshold Pollutant Concentrations (per cubic meter of air)		
Pollutant	Standard	Alert	Warning
Particulates (24 hour)	260 micrograms	375	625
Sulfur dioxide (24 hour)	365 micrograms	800	1,600
Carbon monoxide (8 hour)	10 milligrams	17	34
Oxidants (1 hour)	160 micrograms	200	800

In 1974 (Figure 2), at least 49 of the 363 instances in which health standards were exceeded in Washington involved concentrations at or above the alert level. A third of those more serious conditions occurred in King County.

Figure 2

WASHINGTON

DAYS EXCEEDING HEALTH STANDARD BY SEVERITY



POLLUTANT SOURCES: CARBON MONOXIDE

The graph in Figure 2 indicates the estimated distribution of sources of carbon monoxide in those Washington counties in which a primary air quality standard was exceeded in 1974.

Mobile sources--automobiles and transportation equipment--were responsible for the largest share of carbon monoxide in all of those counties in which the carbon monoxide standard was exceeded, accounting for 85 percent of their gross production, as compared to 10 percent from point sources and 5 percent from area sources. Thus, the predominant source of Washington's air pollution incidents, and the source of the pollution that affected the greatest number of persons, was the automobile, with other mobile sources contributing to its effect.

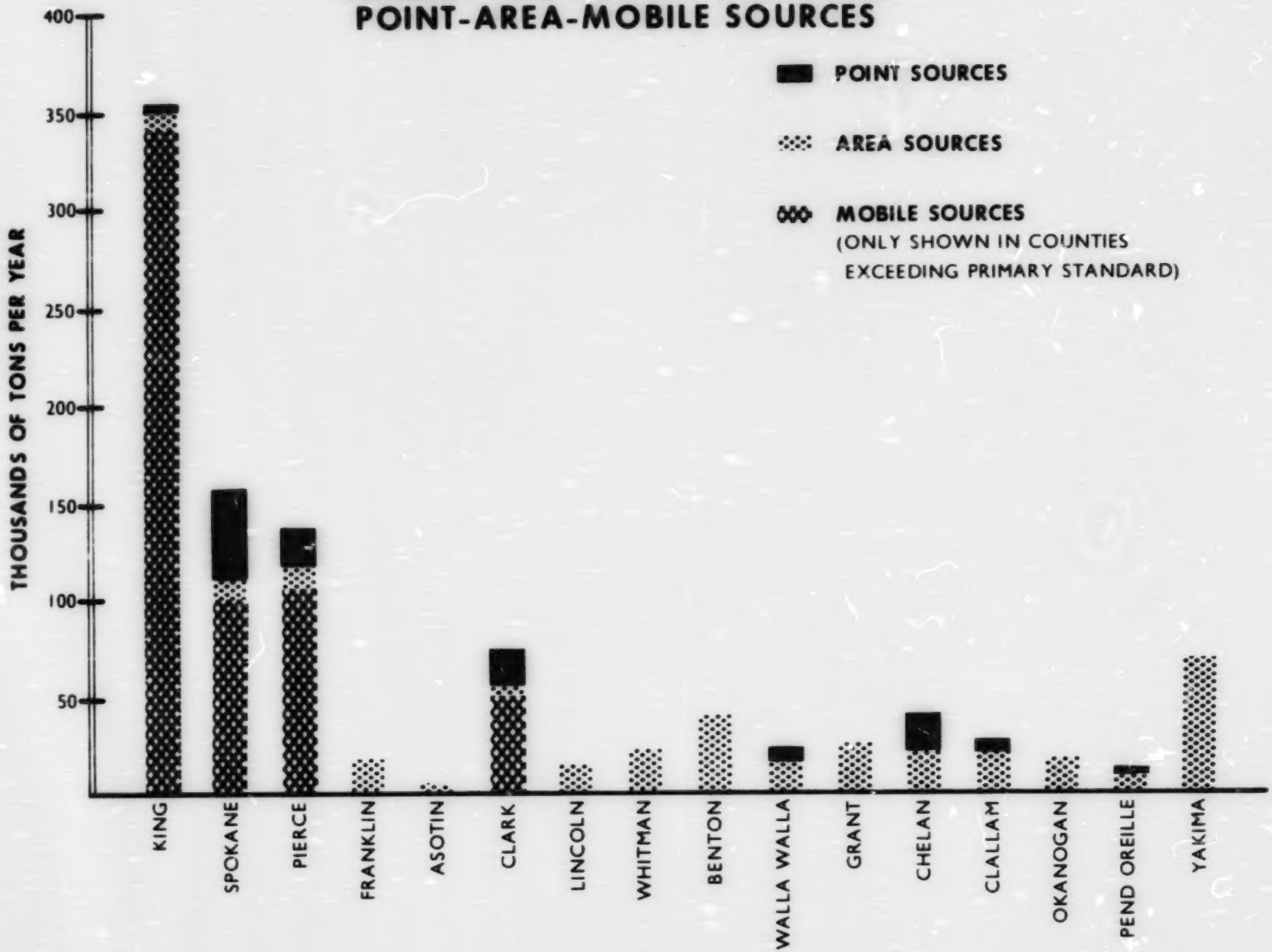
Point sources--large, recognizable features such as factories--were significant contributors of carbon monoxide in Spokane and Clark Counties, where the carbon monoxide standard was exceeded, as well as in Chelan and Pend Oreille Counties where the standard was met.

Area sources (i.e. everything other than mobile and point sources) tended to be of slight consequence. The graph is somewhat misleading in this respect, since mobile source contributions were not calculated for counties in which the carbon monoxide standard was met.

Figure 3

WASHINGTON

CARBON MONOXIDE EMISSIONS POINT-AREA-MOBILE SOURCES



POLLUTANT SOURCES: TOTAL SUSPENDED PARTICULATE MATTER

Figure 4 indicates the estimated distribution of sources of particulate matter in those Washington counties in which a primary air quality standard was exceeded in 1974.

Such point sources--large, recognizable features such as factories--accounted for the bulk of particulate production in the State, as well as in all but two of the total counties in which particulate standards were exceeded. In total, point source particualte emissions amounted to about 46,000 tons of the more than 71,000 tons of particualte matter produced in 1974 for the above counties.

Area sources--space heating, transportation devices, brush and field burning, wind blown dust: the variety of small, intermittent sources of pollutants too numerous and insignificant in themselves to be cataloged --though in combination they may generate large volumes of pollutants--were responsible for less than 25,000 tons of particulate matter.

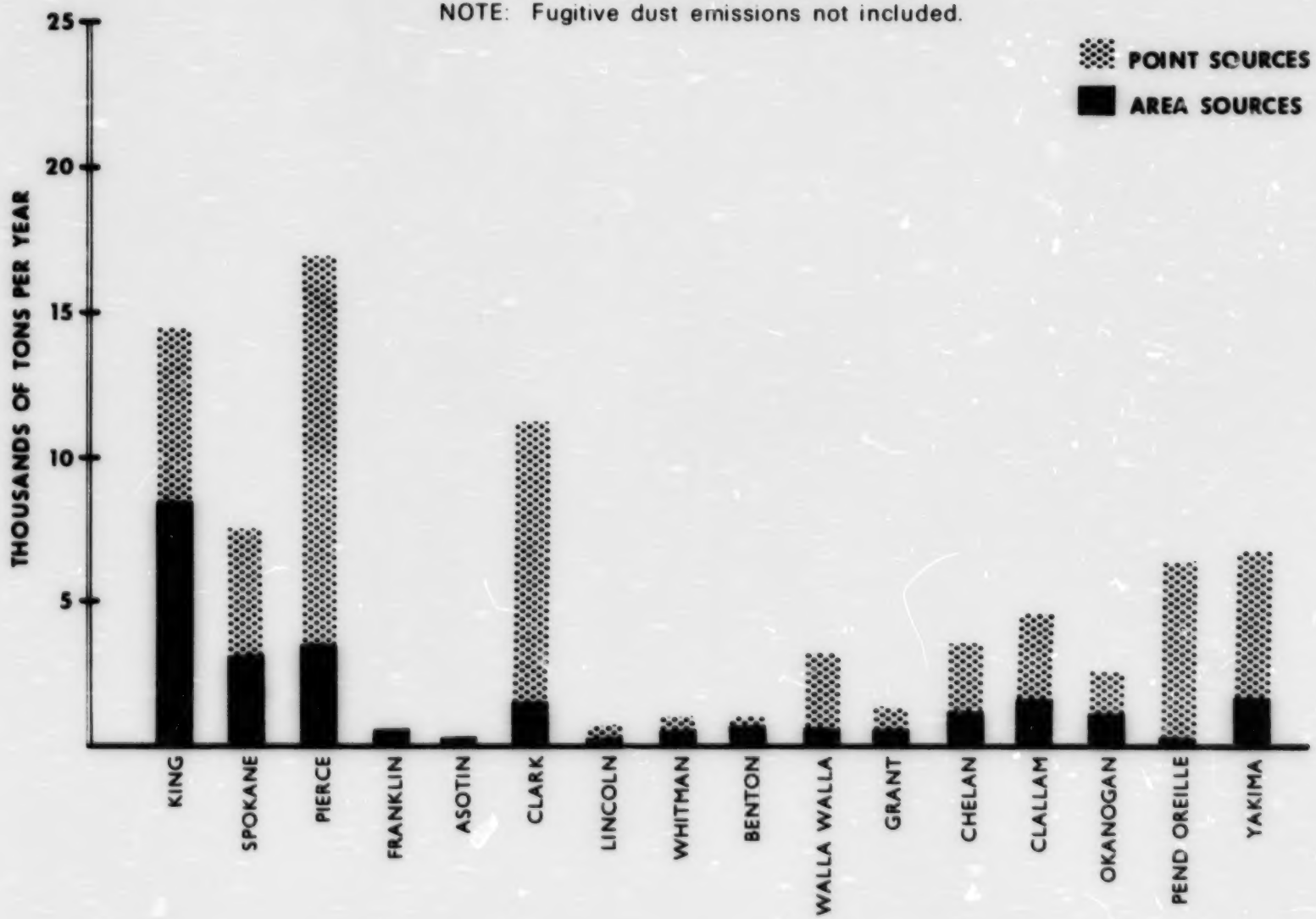
A comparison of the volume of particulate emissions with frequency of violation days does not result in a direct correlation without including the enormous influence of weather on the occurrence of air pollution.

Figure 4

WASHINGTON

POINT AND AREA SOURCE PARTICULATE EMISSIONS

NOTE: Fugitive dust emissions not included.



AIR POLLUTION TRENDS

The chart in Figure 5 shows indicated trends of pollutant concentrations in Washington counties, as those trends may be derived from the air monitoring record for the period 1972 through 1974.

Blue boxes indicate that there is no evidence that the specified primary air quality standard has been exceeded. Where circles occur within the box, the presumed compliance with standards is not based on measurements, but is derived from judgment and a knowledge of pollutant sources.

Yellow boxes indicate that a standard has been exceeded, without concentrations reaching the alert level. An upward pointing arrow indicates that measured concentrations of the specified pollutant appear to be increasing--that the propensity for pollution to occur is rising. A downward pointing arrow indicates that concentrations appear to be receding.

Red boxes are used where a pollutant concentration has exceeded the alert level. Again, the arrow within the box indicates the apparent direction of the pollutant's concentration.

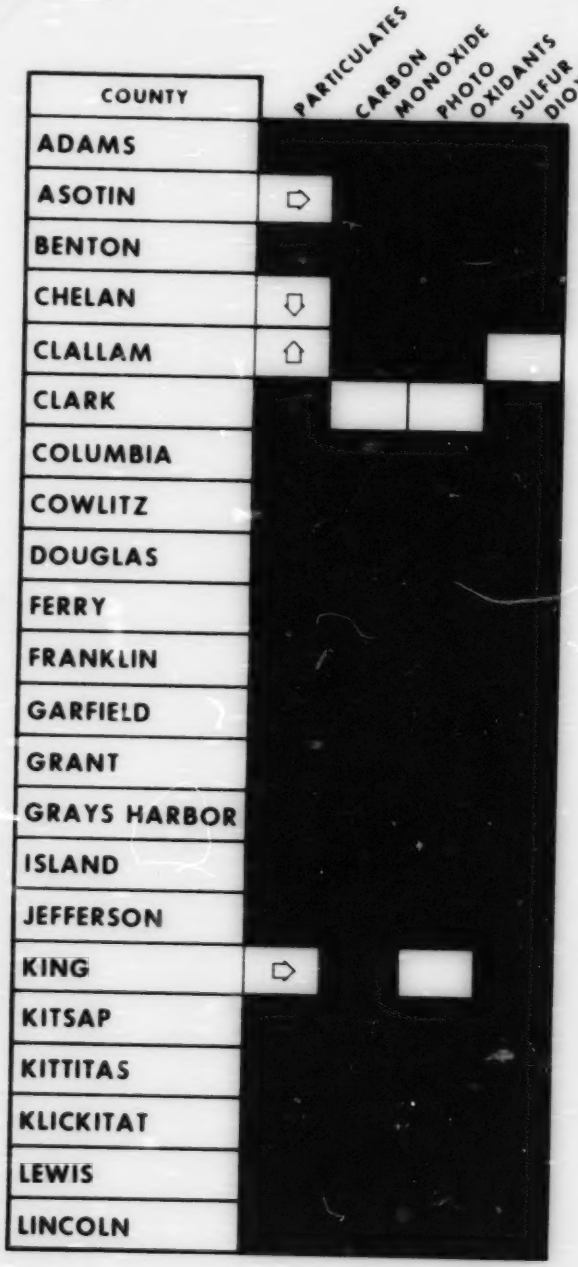
On balance, there appears to have been little change in the State's air quality situation between 1972 and 1974. A note of optimism is afforded by the apparent decline in Seattle's carbon monoxide situation. Fluctuating meteorological conditions, however, make it unwise to attempt to extrapolate the trend.

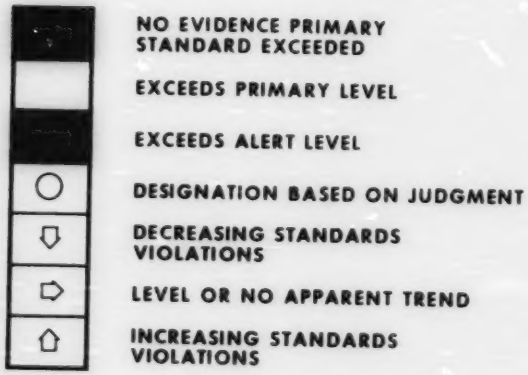
The central feature of the display is the preponderance of blue. Clearly, air pollution exceeding health standards is not widespread in Washington. The limited cases in which primary standards are exceeded tend to be of slight duration, and seldom reach the alert level. Air quality in Washington appears to show little disposition to become less acceptable. Thus, for most of the State, the regulatory goal is one of protecting against degradation of good quality air.

Figure 5

ATTAINMENT STATUS AND TRENDS IN AIR POLLUTION

WASHINGTON





NEAR TERM OUTLOOK

With the exception of the Seattle and Spokane area's carbon monoxide concentrations, Washington's air quality must be conceded to be generally good. Existing trends indicate no imminent threat of deterioration; and there is nothing in the review of the kinds, frequencies, and sources of pollutant concentrations that exceed the standards to indicate a turn for the worse. As for existing air pollution, the prognosis varies according to pollutant.

Particulates, the broadest form of pollutant in excess of standards, would seem to offer the brightest prospects for immediate improvement. Though excessive particulates are widespread, the frequency and the duration of concentrations in excess of the primary standard are generally slight. Point sources predominate; and the combination of source identification with the availability of reliable and relatively inexpensive control technology indicates that improvement is possible. Indeed, a good deal of the State's particulate problems had been corrected by precisely that combination of circumstances prior to 1972. Total elimination of particulate concentrations in excess of the standard is not feasible because of such over-riding natural mechanisms as wind blown dust--particularly in eastern Washington agricultural areas--and forest fire. But the bulk of controllable particulate-associated air quality problems is very likely to be eliminated within the next three to five years.

Sulfur dioxide in excess of primary standards offers the same favorable conditions for control--source identification plus demonstrated control technology--as do particulates. The situation is complicated by process changes at the source and difficult meteorological conditions; but the prospect of virtual elimination of excess concentrations in the immediate future is good.

Carbon monoxide and associated photochemical oxidant excursions beyond the standard present distinctly less optimistic prospects. The private automobile is responsible for almost 85 percent of carbon monoxide production in those counties where the standard is not met, so that the very number of sources that must be controlled presents a formidable obstacle to near term standard attainment. Carbon monoxide reduction devices are, of course, an integral component of all recent model autos. So the reduction of carbon monoxide concentrations is essentially a matter of gradual replacement of the existing stock of autos with newer units that incorporate the control technology--a long term probabilistic process that is retarded by growth in total automobile usage. This approach assumes that these devices are operated and maintained properly which requires an inspection and maintenance program. Modifications of transportation practice have the power to accelerate the rate of cleanup: reduction of use of high density traffic corridors, smoothing of peaks in traffic patterns, greater attention to auto maintenance, and reduction of total vehicle miles through growth in average numbers of passengers per

vehicle by use of mass transit or other techniques all offer marginal improvements in carbon monoxide production trends. But the main avenue of pollution control at this time is replacing older autos with ones having adequate emissions control. That suggests that the advance toward conformity to the carbon monoxide standard over the next three to five years will be steady but slow--certainly less rapid than is desirable to assure the protection of the public health.

REGIONAL WATER QUALITY PROFILE

OVERVIEW

Relative pollution of the non-marine waters of major Pacific Northwest rivers is indicated on the accompanying graphs. Figure 6 depicts the degree of pollution in each major regional river reach and Figure 7 shows the location of the river reaches. Similar determinations are not available for Alaskan waters due to a lack of necessary data. EPA and the State of Alaska are currently working together toward the development of a water quality monitoring program that will provide the same depth of information that is available in other Region X states.

The basis of comparison between waters of the Pacific Northwest is an eleven part Water Quality Index (WQI) that compares measured water quality conditions during the last five years with federal criteria recommended by the National Academy of Sciences.1/ Approximately four hundred (400) water quality stations located on a majority of the streams throughout the three Northwest states were used in the evaluation. Measured water quality constituents from various federal, state and local agencies are stored in EPA's data storage and retrieval system called STORET. The federal water quality criteria are recommended threshold concentrations in water which are considered suitable for propagation of fish, the use by wildlife, and for recreation. The eleven criteria groups considered in the index are listed in Table 5.

The index number for any river segment is calculated by multiplying the frequency of criteria violations for each constituent by a severity weighting function which is based on the magnitude of violation. Individual river segment index numbers are multiplied by a ratio of segment river miles to total river miles, then summed to obtain average WQI for the total river. The WQI number spans a scale that may run from 0.0 (no measured evidence of pollution) to 110.0 (severe pollution in all criteria groups at all times); however, most Pacific Northwest streams fall into a category below the scale of 20.0. General, federal criteria were employed for the particular index construction rather than the specific state water quality standards that apply to the various waterbodies. State water quality standards reflect local natural conditions whereas federal criteria are based upon field and laboratory studies which have been shown nationally to correlate with biological, recreational, and health problems. Federal criteria are in some cases more stringent than state standards. Index values computed from federal criteria will therefore tend to present a more conservative estimate of water quality than if actual state standards were applied.

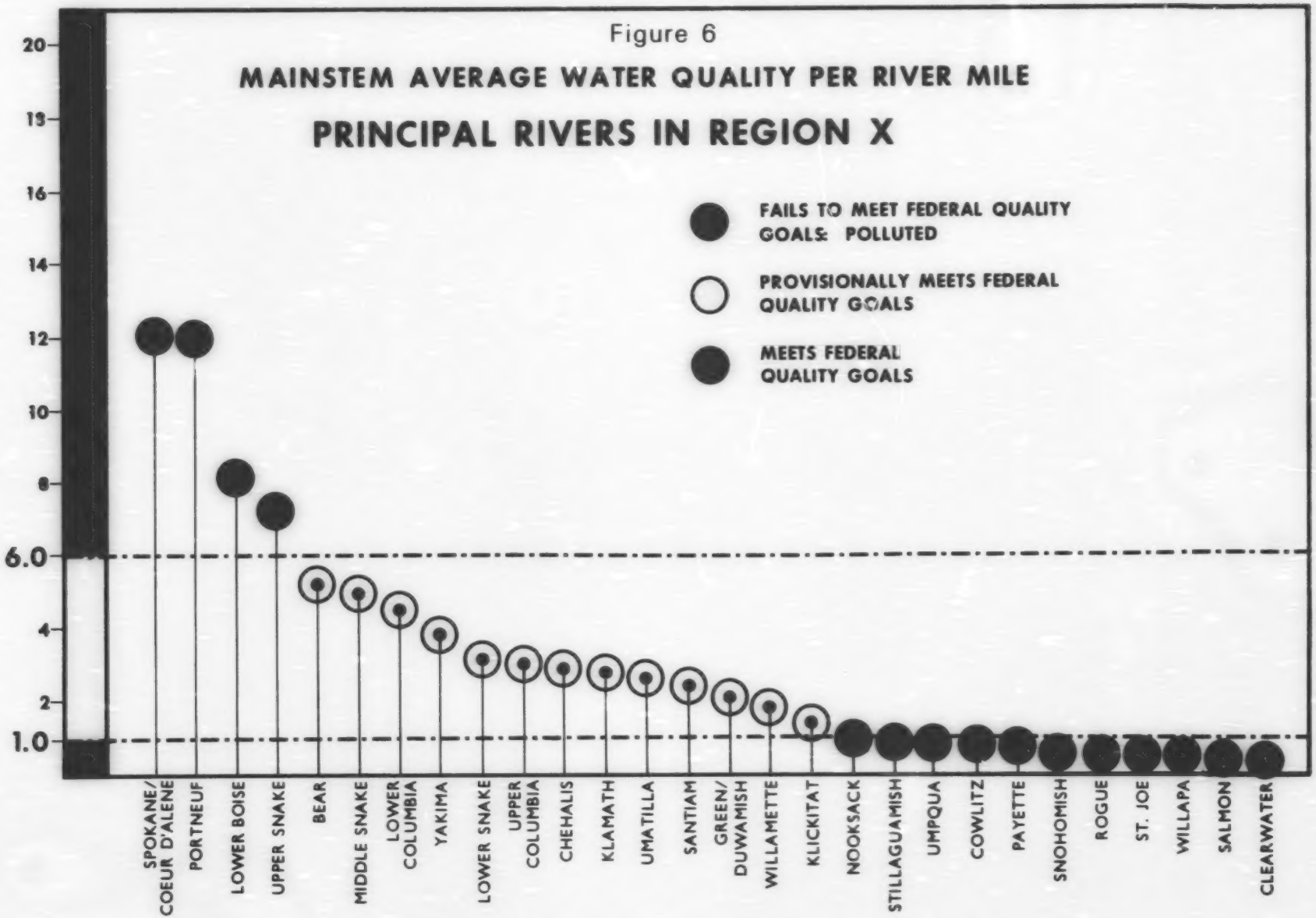
The graphs of water quality indices are divided into three segments that reflect professional judgment as to the significance of the values. An index number greater than 6.0 is considered to be characteristic of streams or stream segments that do not meet the goals of the Federal

1/ EPA R3.033 Ecological Research Series, Water Quality Criteria 1972, U.S. Government Printing Office, March 1973.

Figure 6

MAINSTEM AVERAGE WATER QUALITY PER RIVER MILE

PRINCIPAL RIVERS IN REGION X



Water Pollution Control Act--bodies of water that are, based upon federal criteria, definitely polluted. An index number less than 1.0 is considered to be equivalent to unpolluted natural conditions. The area between 1.0 and 6.0, where most Pacific Northwest rivers fall, is generally consistent with the goals of the Federal Water Pollution Control Act, but with local or seasonal deviations.

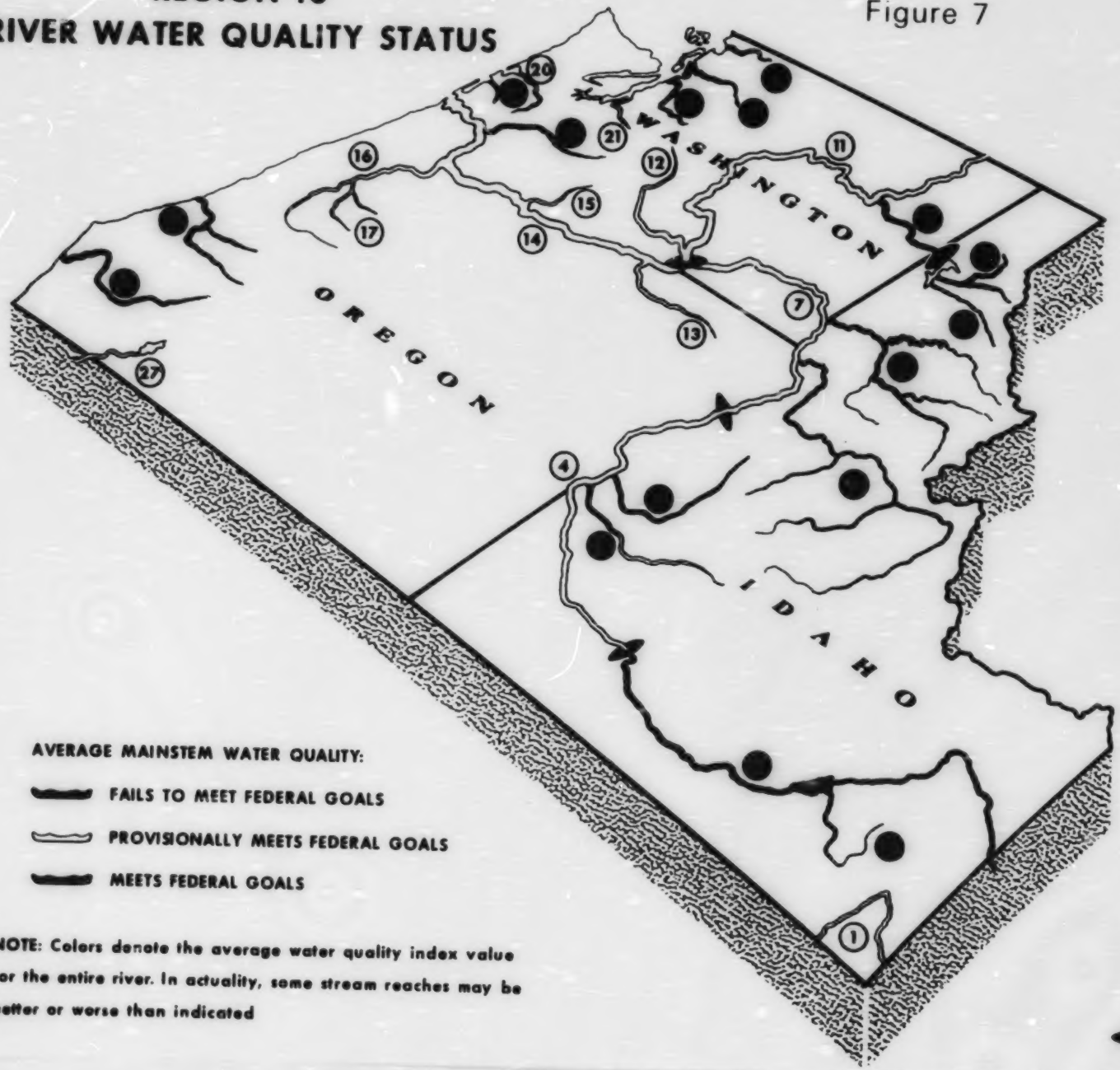
The water quality index is used in this report for the purpose of comparing twenty-eight Pacific Northwest rivers within the States of Idaho, Oregon, and Washington. In each major river discussed in this section, the WQI is a summation of the significant individual stream segments that make up each river. The resultant river WQI is the weighted average of the individual WQIs within the river and may not reflect local pollution problems existing in some of the individual segments. For ease of presentation, colors on Figure 7 represent the average WQI range for the mainstem of each river; however, the actual WQI could change throughout each river segment.

As Figures 6 and 7 indicate, all but four of the major rivers of the Pacific Northwest generally meet the goals of the Federal Water Pollution Control Act; however, three rivers have index numbers that are perilously close to the 6.0 that indicates unequivocal pollution. It is apparent that the more arid and agriculture oriented parts of the Region have the worst pollution. The Upper Snake River and its tributaries--the Boise and Portneuf Rivers--are three of the four worst polluted rivers in the Region. The fourth river, Spokane/Coeur d'Alene, is located in an intensive mining and smelting area. Other streams that flow through major agriculture areas include the Middle Snake, Yakima, and Bear Rivers. These streams have higher index numbers than most of the remaining rivers within the Region. Major coastal, major mountain, and Puget Sound rivers, with a few exceptions, have relatively good water quality. The exceptions, Green/Duwamish and Chehalis Rivers, flow through major populated areas.

The most prevalent of the eleven classes of pollution (see Table 5 below) that make up the index are excessive bacterial populations which indicate the possible presence of disease-related bacteria and viruses (Pathogenic indicators), excessive concentrations of phosphorus and nitrogen which have been documented to be the major nutrients responsible for eutrophication in the Region (Trophic potential), and excessive presence of suspended materials or oil and grease (Aesthetics). Each of these three classes of pollution was found to occur in half or more of the twenty-eight Pacific Northwest rivers that were analyzed for this report; and each at this time appears to be associated predominantly with runoff rather than waste discharges. High concentrations of toxic organic compounds such as pesticides, dissolved oxygen deficiencies, and elevated temperatures are also common. (The latter two are associated predominantly with reservoir conditions.) Supersaturation of dissolved gasses, heavy metals in toxic concentrations (toxic inorganics), salinity (dissolved minerals), and excessive acidity are also found, though they are rarer forms of pollution in the Pacific Northwest. No excessive concentrations of radioactivity were measured or suspected in the Northwest waters.

REGION 10
RIVER WATER QUALITY STATUS

Figure 7



AVERAGE MAINSTEM WATER QUALITY:

- FAILS TO MEET FEDERAL GOALS
- PROVISIONALLY MEETS FEDERAL GOALS
- MEETS FEDERAL GOALS

NOTE: Colors denote the average water quality index value for the entire river. In actuality, some stream reaches may be better or worse than indicated

STREAMS/REACHES

1. BEAR RIVER
2. UPPER SNAKE RIVER
3. PORTNEUF RIVER
4. MIDDLE SNAKE RIVER
5. BOISE RIVER
6. PAYETTE RIVER
7. LOWER SNAKE RIVER
8. ST. JOE RIVER
9. COEUR D'ALENE RIVER
10. SPOKANE RIVER
11. UPPER COLUMBIA RIVER
12. YAKIMA RIVER
13. UMATILLA RIVER
14. LOWER COLUMBIA RIVER
15. KLICKITAT RIVER
16. WILLAMETTE RIVER
17. SANTIAM RIVER
18. COWLITZ RIVER
19. WILLAPA RIVER
20. CHEHALIS RIVER
21. GREEN/DUWAMISH RIVER
22. SNOHOMISH RIVER
23. STILLAGUAMISH RIVER
24. NOOKSACK RIVER
25. UMPQUA RIVER
26. ROGUE RIVER
27. KLAMATH RIVER
28. CLEARWATER RIVER
29. SALMON RIVER

Selected stream/reach limits

Table 5 - Percent of Regional Rivers
Not Meeting Water Quality Criteria

Class	Criteria Group	Idaho	Oregon	Washington	Regional Avg
1	Bacteria	50%	86%	77%	71%
2	Trophic potential	88%	86%	38%	64%
3	Aesthetics	38%	71%	46%	50%
4	Toxic organics	25%	71%	38%	43%
5	Dissolved oxygen	38%	29%	31%	32%
6	Temperature	25%	29%	15%	21%
7	Dissolved gasses	-	14%	23%	14%
8	Toxic inorganics	25%	-	15%	14%
9	Dissolved minerals	50%	14%	-	18%
10	Acidity/Alkalinity	13%	-	-	4%
11	Radioactivity	-	-	-	-

A pattern of change appears to be evolving in the nature of Pacific Northwest water pollution; though variations in flow, climate, and monitoring make any conclusions with respect to short term trends provisional. As seen on Table 6 below, those pollutants that have historically been associated with waste discharges--bacteria, nutrients, acidity, oxygen consuming substances, heavy metals from industrial operations--appear to be progressively less prevalent in Regional rivers. Conversely, pollutants that are associated with runoff, fallout, intense land use, reservoirs, and in-stream chemical reactions--toxic organic compounds, dissolved gasses, total dissolved solids--would appear to be increasing in prevalence and concentrations. Some of this apparent deterioration may be due to improved analytical capability in recent years.

Table 6 - Water Quality Trends of Regional Rivers

Class	Criteria Group	Improving*	Deteriorating*	No Change*
1	Bacteria	21%	11%	68%
2	Trophic potential	11%	7%	82%
3	Aesthetic	7%	7%	86%
4	Toxic organics	-	25%	-
5	Dissolved oxygen	7%	7%	86%
6	Temperature	-	-	-
7	Dissolved gasses	-	7%	-
8	Toxic inorganics	4%	-	-
9	Dissolved minerals	4%	7%	89%
10	Acidity/Alkalinity	4%	-	-

* Figure represents the precent of streams within the three states which are improving or deteriorating by criteria group. One stream may be improving with respect to one criteria group and deteriorating in another; therefore, it would be included in each listing. If 7% of the rivers in one criteria group are improving and 7% are deteriorating in the same group, then 86% experience no change at all.

The impression that may be derived from the data is that contemporary water pollution strategies based on waste treatment are proving effective with traditional pollutant sources but the more complex and resistant kinds of pollution that stem from intensive use of land and water may be offsetting some part of that improvement.

WATER QUALITY IN WASHINGTON

A review of thirteen major Washington rivers (Figure 8)--the river proper, not the entire drainage system--reveals a water quality pattern that is not inconsistent with that for all Pacific Northwest drainage basins. Marine waters are not included in this evaluation since present WQI techniques only apply to fresh water streams on a river mile basis. An attempt will be made to include marine waters in future reports.

Water quality, as reflected by an index number, tends to improve progressively from east to west. The Spokane River which has the highest WQI, is balanced by a group that discharges directly to the Pacific or to Puget Sound waters that are so slightly, or so infrequently, polluted that their quality varies insignificantly from Federal criteria.

Aside from the general propensity of rivers on the east side of the Cascades to demonstrate higher concentrations of phosphorus and solids and higher temperatures than west side streams, there is little pattern to the occurrence of water pollution in Washington. Each river seems to exhibit quality degradation tendencies that stem from its own circumstances.

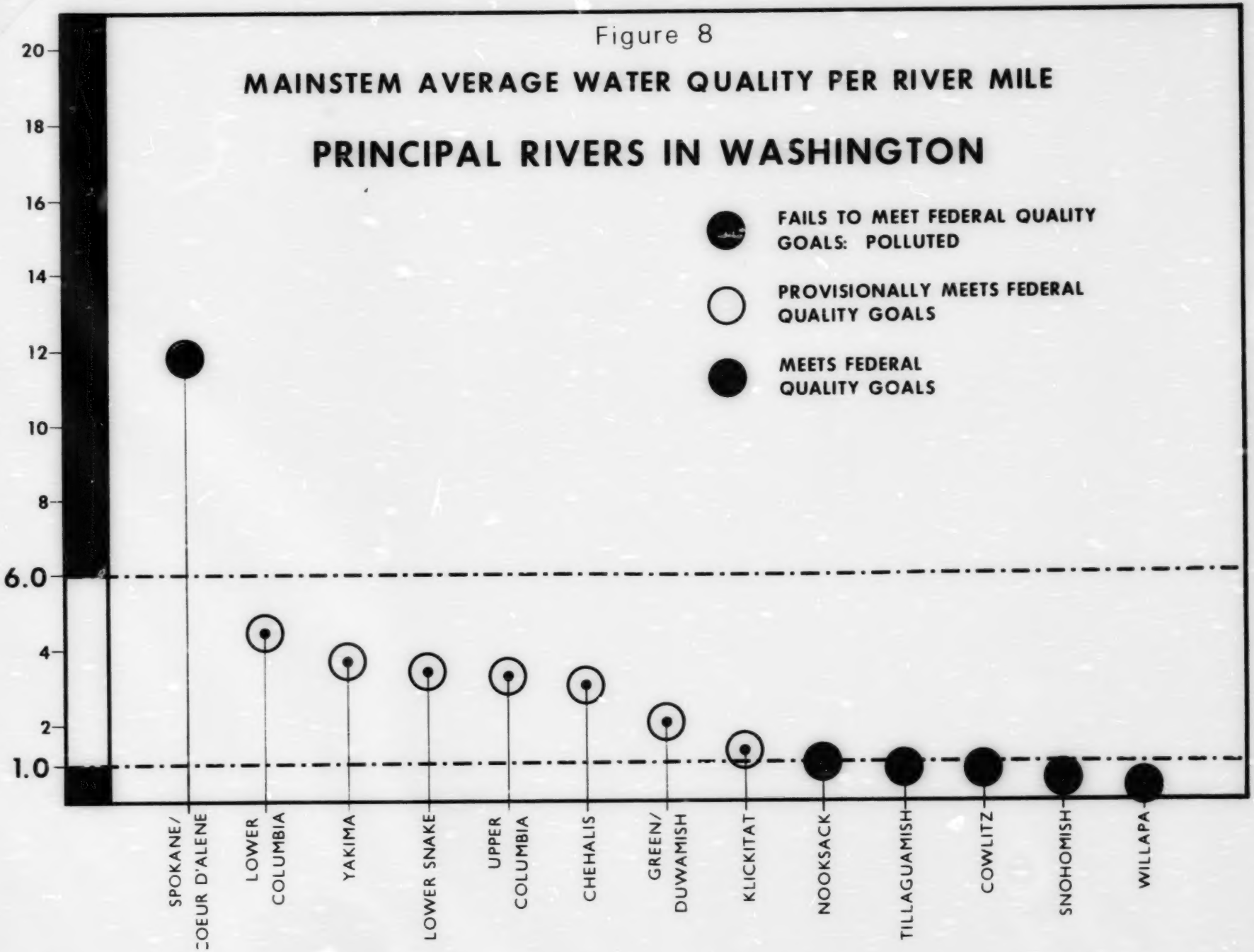
Thus two major rivers, the Spokane (including its Idaho reach) and lower Columbia, have higher index numbers than the river basin system in which they are included, due to particular conditions that impinge on the river without equally affecting its tributaries. The Spokane contains excessive concentrations of dissolved metals through its entire length of passage below the Kellogg-Wallace mining/smelting complex; while the Columbia suffers annually from dissolved gas supersaturation caused by spilling of flood season high flows over its numerous dams. Both situations run counter to the general principle that water pollution tends to be inversely related to volume of flow. In the cases of the Green/Duwamish and Yakima Rivers, the mechanics of index construction conceal local pollution. Both streams are of good quality over most of their length, but are degraded in their lower reaches.

Nonetheless, the picture of Washington's water quality that emerges from the index and from consideration of particular pollutants and stream reaches is encouraging. Only the Spokane demonstrates a high, consistent degree of pollution. Coastal streams are of near natural quality. The east side tributaries of the Columbia largely meet Federal criteria. There is no question, that at this time, pollution is a limited and specialized condition in the waters of the State of Washington. A comprehensive pollution control program is necessary, however, to eliminate the remaining problems and to maintain the quality achieved.

Figure 8

MAINSTEM AVERAGE WATER QUALITY PER RIVER MILE

PRINCIPAL RIVERS IN WASHINGTON



POLLUTANT SOURCES: SUSPENDED SOLIDS

Suspended solid materials constitute the most abundant pollutant in the waters of the Pacific Northwest. An average of 260 million pounds per day are carried to the mouth of the Columbia, though the volume varies enormously with streamflow, precipitation and reservoir operating patterns.

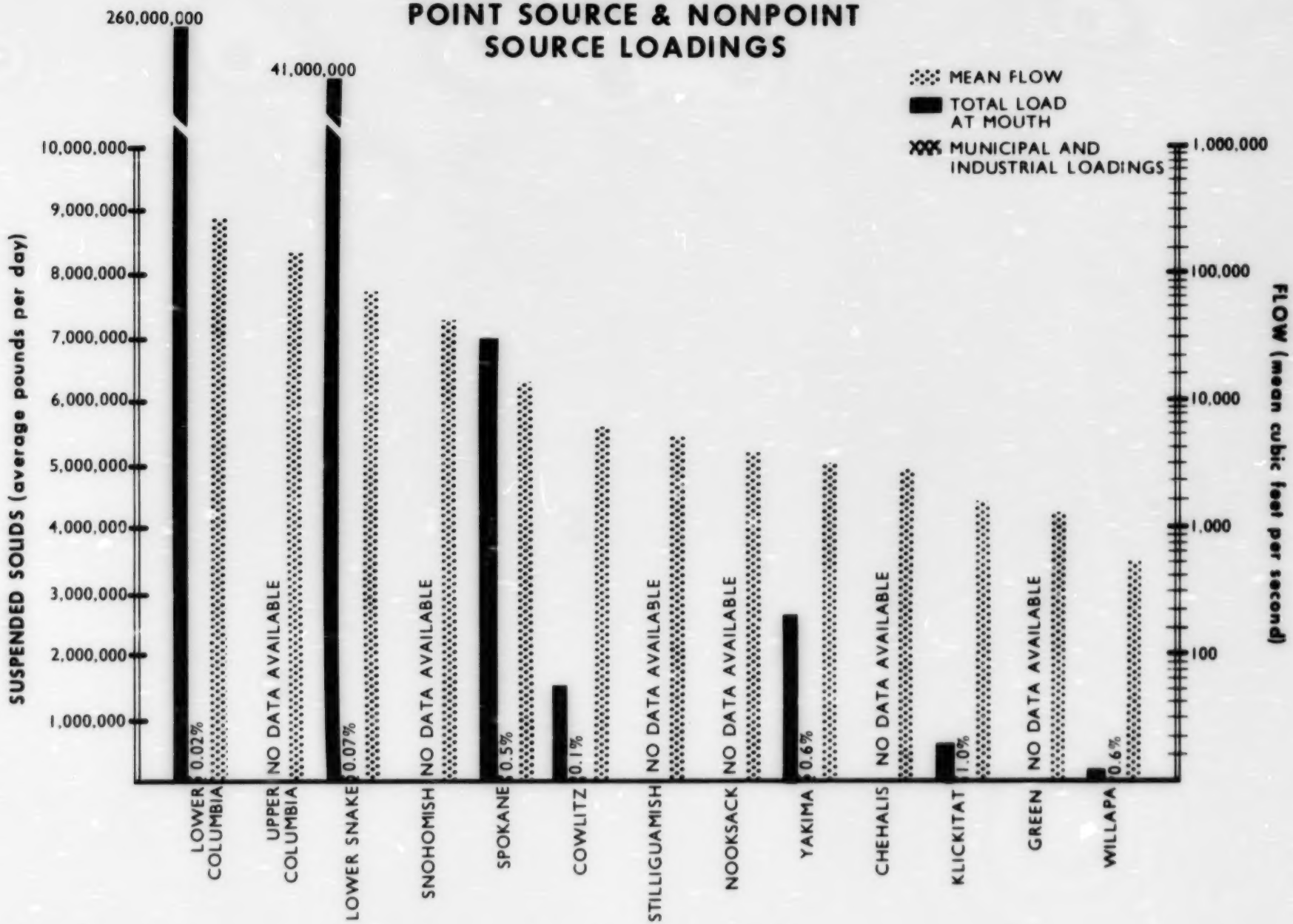
Suspended solids are not a single pollutant, but a general class of materials that are characterized by having a specific gravity close to 1.0. Thus they include both inert materials and organic matter--some of it, such as algae, living organisms. The specific polluting mechanisms of suspended solids are reduction of light penetration, discoloration, and with gradual settling, silting of fish spawning gravels and other ill effects of sediments. In addition to the specific effects of this general category of pollutant, suspended solids are indicators of other potential for pollution: the organic fraction is degradable, so a source of oxygen demand; and suspended materials are carriers of both nutrients (primarily phosphorus) and of toxic materials which ultimately may be released.

There is a pattern to the production of suspended solids in Washington rivers. The mean concentration of suspended solids in the rivers evaluated as indicated by average flows and solids weights in Figure 9, is about 125 parts per million of water, but while the average values for those streams originating on the west banks of the Cascades and flowing directly to the Columbia or to salt water are less than half of that. Streams in the relatively arid area east of the Cascades, however, carry higher loads of suspended solids. Suspended solids data are not available for the Upper Columbia and Puget Sound streams for this documentation. Puget Sound streams contain high levels of suspended solids; however, these are mainly of natural origin resulting from glacial runoff.

Direct industrial and municipal waste discharges are an insignificant source of suspended solids. Aggregated waste discharges amount to only 0.1% of the total suspended solid load for all of the seven rivers studied --this in spite of an aggregation technique that significantly overestimates discharge-related solids loading. (No allowance is made for settling or decomposition.) There is, however, a chain of biological reaction through which the effect of such discharges with respect to the total quantity of solids is amplified. Given favorable conditions, nutrient phosphorus from waste discharges can promote algal growth that is roughly 120 times the dry weight of the available phosphorus, with an even greater expansion of volume. Waste discharges may, then, be a substantial indirect source of suspended solids under some specialized circumstances.

Figure 9

RIVERS IN WASHINGTON
POINT SOURCE & NONPOINT SOURCE LOADINGS



POLLUTANT SOURCES: BIOCHEMICAL OXYGEN DEMAND

Biochemical Oxygen Demand (BOD)--the rate at which oxygen is consumed by populations of aquatic bacteria that utilize dissolved organic materials as nutrients--has been used as the prime measure of a stream's pollution for the better part of a century.

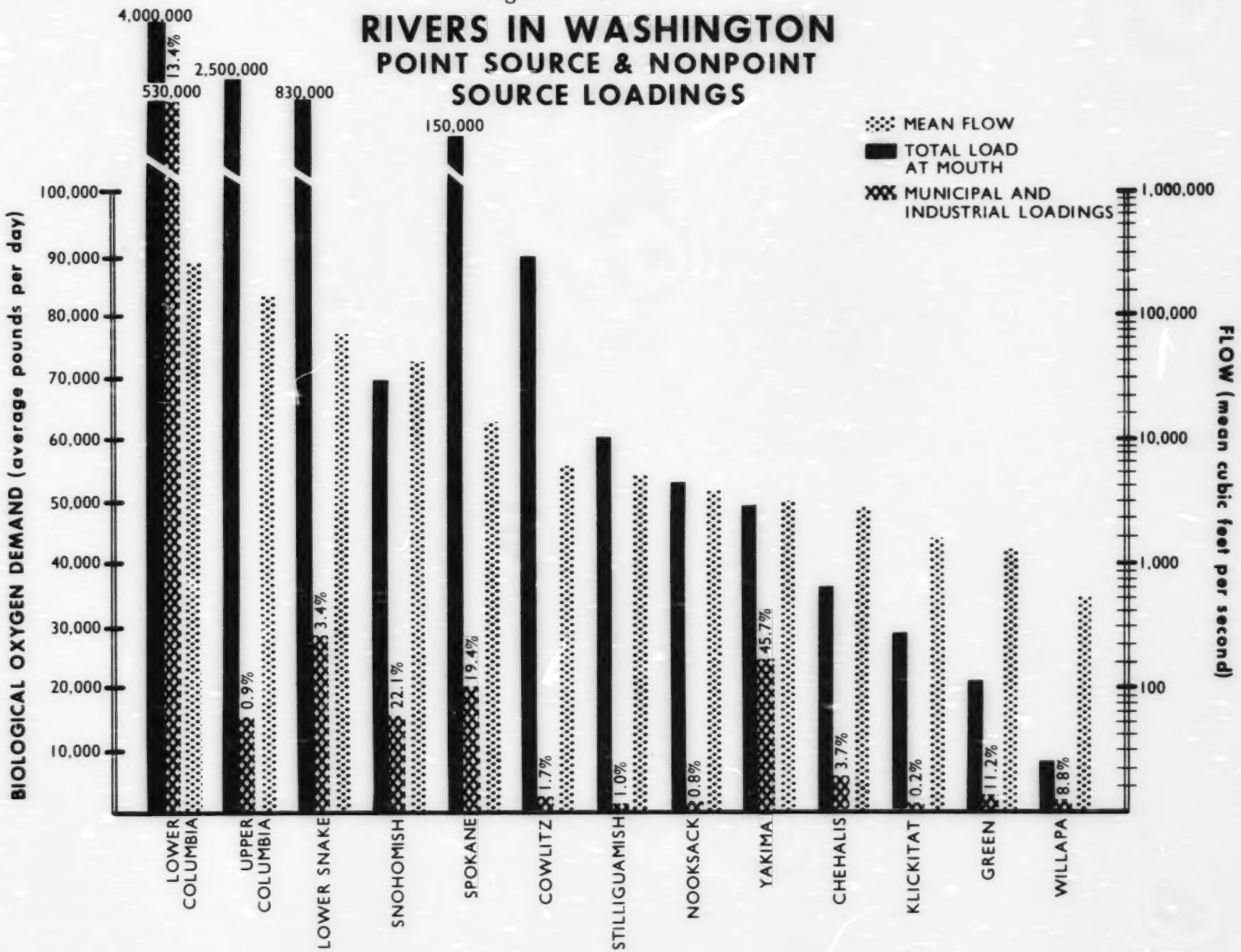
When exerted at a rate in excess of the rate of reoxygenation, biochemical oxygen demand may reduce the amount of oxygen that is dissolved in water sufficiently to change the composition of aquatic lifeforms in the area of the stream that is affected, as well as to reduce its level of biologic activity. The pollutant also serves as a measure of the potential organic enrichment of a stream, enrichment that may support regrowth of bacterial populations or contribute through decomposition processes to nuisance proliferation of algae and other aquatic plants.

As the graph in Figure 10 demonstrates, all of the thirteen Washington streams or stream segments exhibited very similar mean biochemical oxygen demand levels. The average concentration was about two parts per million at the mouth in all cases but that of the Snohomish River, where the concentration was little more than 10% of that for other rivers. These levels are approaching what can be considered background levels for good quality streams. As the graph suggests, rivers rising west of the Cascades (exception, the Duwamish) tended to have slightly lower BOD concentrations than eastern tributaries of the Columbia; though the differences are so slight as to be insignificant. At the mouth, then, Washington rivers uniformly seem to exhibit what are little more than natural background levels of organic materials. (Which is by no means inconsistent with the possiblility of excessive BOD concentrations along the reach of some of the streams, since BOD is not a conservative pollutant and may be exerted over a short reach of stream.

What is extraordinary about the BOD regimens of these streams is the slight contribution that industrial and municipal wastes make to the total BOD load. It has generally been assumed that BOD was essentially a measure of the strength of such point discharges; but even by a method that exaggerates their relative influence (sum of discharges over the length of the stream related to gross BOD exerted at the mouth) only three of thirteen waterbodies--the Snohomish, Spokane, and Yakima--demonstrate a significant contribution from waste discharges, and none derives a majority of its BOD from such discharges. For the group of waterbodies, only 13% of all BOD at the mouth can be attributed to industrial and municipal wastes. For seven of the thirteen, less than 5% can be attributed to discharges. Clearly, at the level of waste treatment achieved in the Pacific Northwest, BOD production is analogous to that of suspended solids, with runoff and other natural mechanisms outweighing waste discharges in the transport of degradable organics to streams.

Figure 10

RIVERS IN WASHINGTON
POINT SOURCE & NONPOINT SOURCE LOADINGS



POLLUTANT SOURCES: TOTAL PHOSPHORUS

Phosphorus is present in Washington streams in minute quantities--an average load of 90,000 pounds a day at the mouth of the Columbia, as contrasted to 260 million pounds of suspended solids or the 4 million pounds of oxygen demand created by dissolved organic matter. Yet the amount is sufficient that phosphorus may be regarded as one of the more significant pollutants in Washington streams.

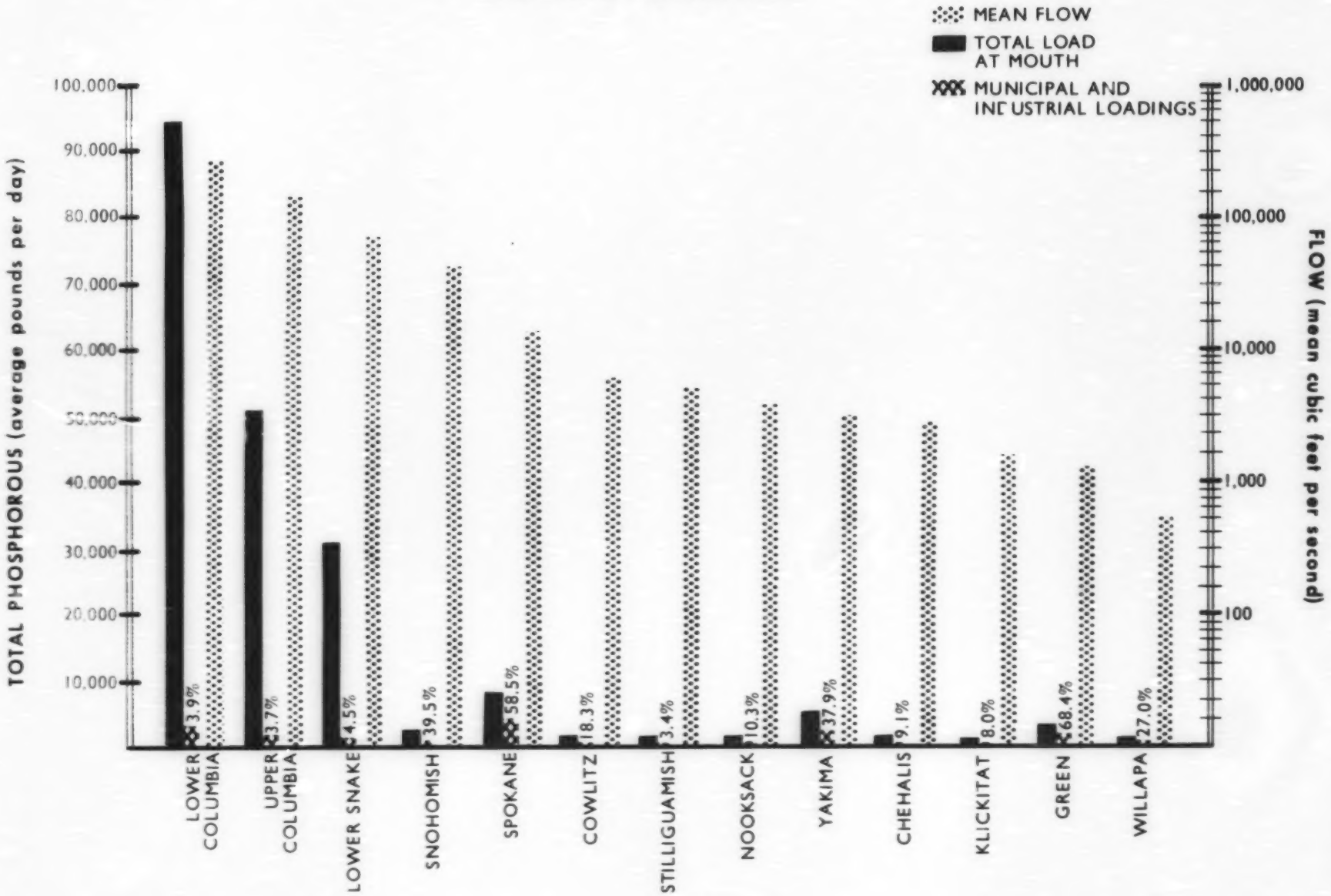
Phosphorus is not in itself a pollutant. Rather, it is the ability of phosphorus, as the critical nutrient, to support growth of nuisance levels of aquatic plants that makes it a potential problem. The approximate balance of the major chemical components of algae and other water plants is 106 parts carbon, 16 parts nitrogen, 1 part phosphorus. Since some aquatic plants can draw both carbon and nitrogen from the atmosphere, the effective limit of plant populations is often dictated by the amount of phosphorus dissolved in water; and each unit of phosphorus may trigger more than 120 times its weight in plant growth. The matter is not quite so simple as the above would make it seem. Trace nutrients and sunlight are also necessary for plant growth; and the form in which phosphorus occurs has a prime influence on its nutrient effect. Where dissolved phosphorus is immediately available as a nutrient, organically linked phosphorus becomes available gradually through decomposition processes, and soil bound phosphorus may never be available to plants unless released into the water column through chemical and bacteriological processes which occur under anerobic bottom conditions.

The pollutional aspects of excessive biological activity that stems from high nutrient levels are diverse. To some degree they may be merely aesthetic--stream discoloration and presence of clumped, floating water weeds--but more fundamental ecological alterations are also involved. Because of the photosynthetic respiratory cycle (plants give off oxygen in sunlight, consume it at night) variations in daytime and nighttime dissolved oxygen concentrations may occur that produce extreme stress on fish life. Similar diurnal variations in acidity and alkalinity may occur. Light penetration is reduced. Decay of dead material that settles out in lakes or reservoirs may produce oxygen deficiencies. The enriched environment is favorable to regrowth of bacteria. Loss of species balance in fish populations follows from specialization of the organisms that fish feed upon. The taste and odor of water may be altered disagreeably, and carrying capacity of pipes and channels may be reduced.

The phosphorus production regimens of Washington streams vary with location as can be seen on Figure 11. There is a rule of thumb that holds that, with the normal distribution of phosphorus forms, a concentration of .05 parts or more per million parts of water can result in nuisance algae growths. Virtually all Washington streams that originate east of the Cascade Mountains exceed that level--some by a factor of ten or greater. Conversely, west side streams tend to support concentrations distinctly below .05. Thus, for example, the Spokane and Yakima Rivers, which

Figure 11

RIVERS IN WASHINGTON
POINT SOURCE & NONPOINT SOURCE LOADINGS



together provide about 5% of the Columbia's flow, provide close to 15% of its phosphorus; and the Snake is responsible for 20% of the flow of the Columbia and 35% of its phosphorus. Conversely, the Cowlitz, a typical west side stream, balances 2% of the Columbia's flow with only 1% of its phosphorus.

Over all, municipal and industrial waste discharges are a minor source of phosphorus, about 4% for the thirteen Washington Rivers used in this analysis. But for several reasons, those discharges are a more significant contributant to pollution potential than their gross amount would suggest. As the graph demonstrates, waste discharges provide the largest relative share of phosphorus in precisely those streams that carry the greatest phosphorus concentrations--the Spokane, the Yakima, and the Duwamish, all rivers with definite problems of excess productivity. High relative waste contributions are also found in certain west side streams--the Snohomish, Willapa, Cowlitz, and Nooksack, for example--where natural phosphorus sources are scarce. The total load is fairly low, however, and concentrations in these streams are well below the problem level. More significant, perhaps, than the distribution of waste-originating phosphorus concentrations is their form. The accelerated decomposition of organic matter that occurs in waste treatment results in a discharge whose phosphorus content is largely in solution, thus immediately available as a growth-triggering nutrient; while much, if not most, of the phosphorus originating with runoff is soil bound and not available to algae. Thus both the form and the distribution of that phosphorus that occurs in discharged wastes tends to give it a disproportionate pollutional effect.

WATER POLLUTION TRENDS

Figure 12 depicts the presence and trends of eleven broad classes of water pollution as they are revealed by the monitoring record for major Washington rivers in the period 1971 through 1975.

A blue box indicates that measurements for the indicated class of pollutant produced no evidence of a violation of Federal criteria for water suitable for fish, wildlife, and recreation. Yellow and red boxes indicate respectively that there were relative minor and major violations of the criterion. The color determination takes into account the frequency and magnitude of the violation as well as the water quality sampling frequency. An upward pointing arrow within the box indicates measurements that show either that the concentration of the particular pollutant is rising or that the frequency of criterion violation is increasing--that is, that the propensity for pollution to occur is rising. (A downward pointing arrow would indicate a decline in the propensity for pollution.) A circle within the box indicates a judgment based on knowledge of pollutant sources rather than actual water quality measurements.

As Figure 12 demonstrates, the most common criteria violations in Washington are those derived from bacteria counts and trophic conditions; but these, on balance, are declining with the exception of the Yakima and Spokane Rivers.

Violation of aesthetic and trophic criteria follow bacteria in frequency. Trophic violations are more common in eastern than in western Washington rivers; whereas, bacteria and aesthetic appear to be equally spread throughout the State.

Excess concentrations of toxic organic compounds are also common; and appear to be increasing in the Green/Duwamish, Snohomish, and Chehalis Rivers, however, only the Green/Duwamish stream is considered serious at this time.

Dissolved gas supersaturation is the most serious form of pollution in Washington waters because of its catastrophic and widespread effect on salmon populations and would appear to be stable or increasing in the two rivers in which it occurs.

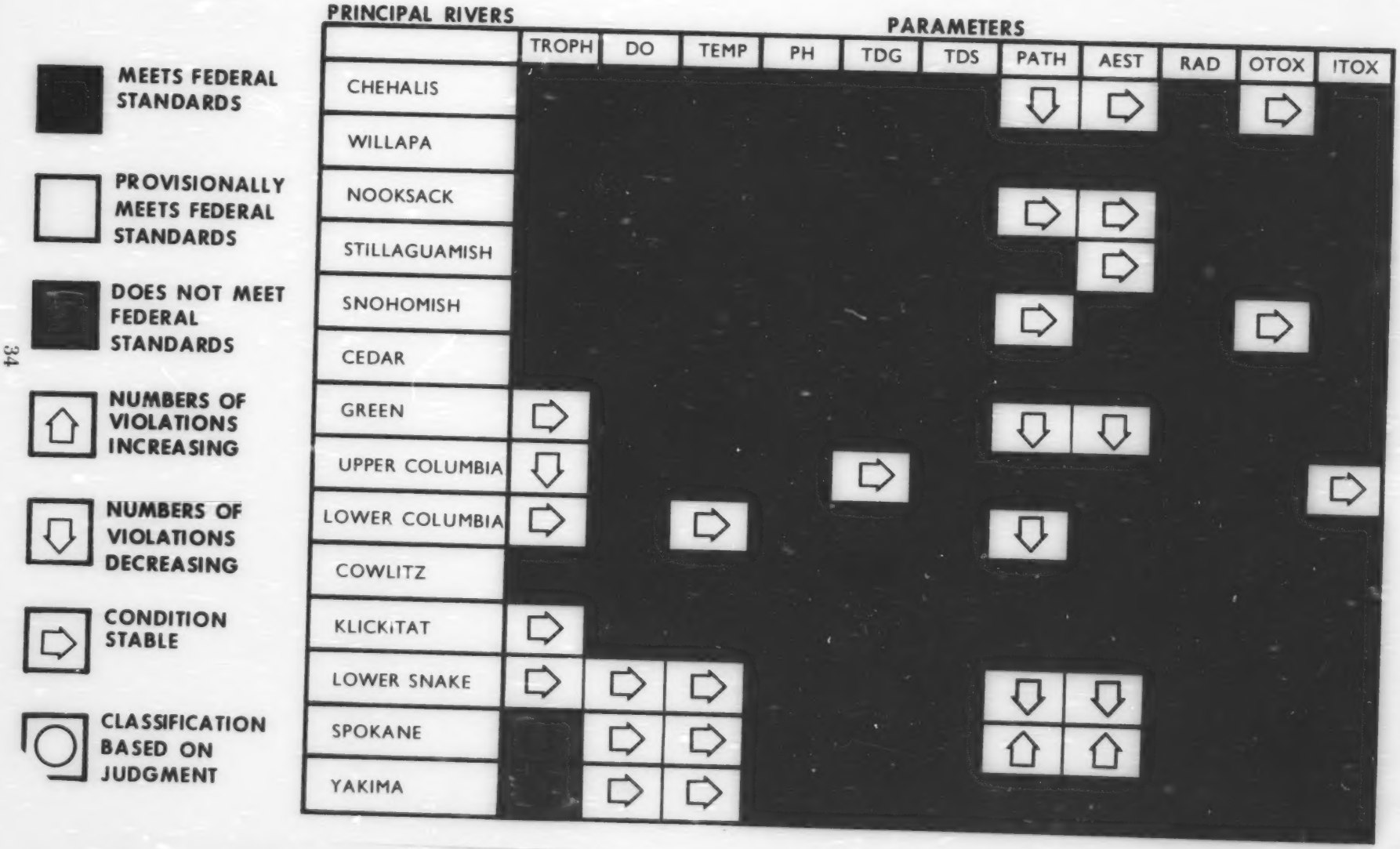
Other pollutant presences appear to be stable. In fact, the State's water quality situation seems to display a static balance. Of 143 opportunities for water pollution (eleven pollutant classes, fourteen studied rivers), thirty-eight suggest that some degree of pollution is, in fact, realized. In eight of the 143, the propensity for pollution seems to be declining; in thirteen it appears to be increasing.

In view of the good overall water quality that predominates in Washington, the static balance may not be unfavorable--though it is clearly

Figure 12

RIVERS IN WASHINGTON

FEDERAL CRITERIA VIOLATIONS



less than ideal. There are, however, disturbing implications in the distribution of improving and declining pollution indicators. Improvements are concentrated in the class of pathogenic indicators, where their effects must be conceded to be slight. Worsening conditions are dominated by concentrations of toxic organic materials that may have serious and far reaching effects on aquatic ecosystems.

There is another disturbing feature about the thirteen cases of declining water quality indicators. The majority of them occur in the Lower Snake (three), Spokane (four), and Yakima (three) Rivers. So it is three of the four most polluted of Washington's streams that appear to be becoming more polluted.

NEAR TERM OUTLOOK

Consideration of the nature, location, sources, and trends of water pollution in the fresh waters of the State of Washington must lead to the conclusion that little significant change can be anticipated in the next three to five years.

The assessment is almost inescapable. With exceptions, the water quality problems in the freshwater areas of Washington do not stem from point source waste discharges, which constitute the near exclusive focus of contemporary water pollution abatement programs, but from runoff and reservoir conditions. Man's activities contribute to the pollutional aspects of natural runoff; but, for the most part, measures to reduce those contributions remain to be defined. And as such definitions occur and are adopted in the State, it must be anticipated that they will be offset to some degree by sheer growth in the scale of human activities and by the complications posed by proliferation of toxic organic compounds. There will, in short, be no convenient technological solution like waste treatment with which to deal with most of the remaining and emerging water pollution problems of the State.

Little aggregate improvement can be anticipated from extension of municipal and industrial (M&I) waste treatment because (as the review of the pollutant sources indicates) M&I point sources of waste are a minor factor in Washington's present water quality situation. But in two quite significant instances, that general lack of impact does not hold. Industrial and municipal wastes are significant sources of pollutants to two of the State's worst water quality problems, the Spokane and lower Yakima Rivers. Improvement of the degree of waste treatment in the two situations may well be the one source from which an overall improvement in the State's water quality may be expected in the next few years.

Recognition of the limited marginal effect of M&I waste treatment, the significance of non-point sources of pollution, and the difficulties of dealing with such sources, then, leads to the conclusion that no major change in Washington's water quality is in the offing. But that is, on the whole, an optimistic conclusion. There has been serious water pollution in Washington. It has been largely--not entirely--eliminated. The major task of water quality management in the State at this time is protection and preservation of the excellent water quality that predominates. So to preserve existing water quality would be a major achievement. To improve water quality in the Yakima and Spokane Rivers would be even more desirable.

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